Towards Simple and Affordable Central Blood Pressure Monitoring

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Central Blood Pressure (BP) is Physiologically More Relevant than Peripheral BP

- Central BP is an independent and significant predictor of mortality and cardiovascular events in geriatric patients, end-stage renal disease patients, and coronary artery disease patients.
- Central BP is a better discriminator of age and coronary artery disease severity.
- Current clinical protocols are built on the BP cuff readings from brachial artery. However, recent studies have shown that central cardiovascular risk predictors (such as central aortic BP, augmentation index, reflection magnitude and index, and pulse wave velocity) are independent and significantly better predictors of cardiovascular outcomes than brachial BP.

Method 1: Use of Multiple Peripheral BPs

Black-Box Model Transfer Functions

- Transfer functions are represented via finite impulse responses. Damped sinusoidal basis responses are used to reduce the number of parameters for estimation.
- \( h(t) = \sum_j (a_j \cos(\omega_j t) + b_j \sin(\omega_j t)), \quad \epsilon \{0, 1, \ldots, L - 1\} \)

Physical Model Transfer Functions

- Transfer functions are represented via tube-load model.

Method 2: Use of Single Peripheral BP

Pre-Knowledge Plus Physical Model

Steps:
1. Transfer function is defined via a tube-load model.
2. Model parameters are estimated by invoking pre-knowledge of central hemodynamics.
3. Transfer function is applied to peripheral BP to derive central BP waveform.

Advantage: The method requires only one peripheral BP waveform.

Technique 1: Central Blood Flow is Negligible During Diastole

Advantage: The method can also estimate PTT.

Disadvantage: Strong assumptions regarding arterial hemodynamics are required.

Future Research Directions

Derivation of Cardiovascular Risk Parameters

Artery-Tissue-Cuff Viscoelastic Modeling

Non-Invasive Adaptive Transfer Functions

Noninvasive Central Blood Pressure Measurement

<table>
<thead>
<tr>
<th>Technique</th>
<th>Waveform Error [mmHg]</th>
<th>PP Error [mmHg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radial BP</td>
<td>6.6</td>
<td>20.3</td>
</tr>
<tr>
<td>Adaptive TF</td>
<td>3.7</td>
<td>3.6</td>
</tr>
<tr>
<td>GTF (Radial)</td>
<td>6.6</td>
<td>6.7</td>
</tr>
<tr>
<td>PATF</td>
<td>5.1</td>
<td>6.6</td>
</tr>
<tr>
<td>PATF</td>
<td>5.1</td>
<td>7.6</td>
</tr>
<tr>
<td>GTF</td>
<td>6.7</td>
<td>4.6</td>
</tr>
</tbody>
</table>

The technique exploits the tube-load model relating the derivatives of central and peripheral BPs and set the central BP derivative to zero at high sampling rate.

Advantage: PTT can be estimated.

Disadvantage: Strong assumptions about central BP are required.